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(54) FABRICS FOR USE IN HEAT-RADIATING ARTICLES

(71) We, GULTON INDUSTRIES, INC., a corporation organized and existing under the laws of the State of New Jersey, United States of America, located at 212 Gulton Avenue, Metuchen, New Jersey, United States of America, do hereby declare the invention for which we pray that a patetent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fabrics for use in heat-radiating articles, a portion of which comprises a fabric containing electrical resistance filaments capable of providing heat when connected to an electric circuit, and to heat radiating articles containing such fabrics.

In the application to heating homes, there are numerous locations within the home where heat-radiating articles can be used. Currently available electrical heating elements, if used under or in a rug or carpet, or in venetian blinds, curtains, blankets or upholstery, have a hazard that excessively high spot temperatures can be reached if for any reason normal thermal radiation is blocked. Such occurrences could be caused by bunching of curtains, raising of venetian blinds, placement of furniture or toys on the floor or against the heating element.

Another problem frequently encountered with the use of normal electrical heating means for the home is that high voltages are used, which present an obvious hazard. To permit the use of low voltages (about 20 volts) with normally available heating elements involves the use of heavy wires and multiple connections in order to obtain adequate electric currents. Such means would cause ridges in rugs, objectionable bunching in such applications as curtains and generally impair the pleasing and decorative appearance of articles in which heating elements are incorporated.

Other disadvantages associated with a thermal floor covering or other heat-radiating article is that cleaning, repair, and maintenance of the heat unit is frequently required and such units require special devices such as thermostats for controlling temperature.

According to the present invention there is provided a fabric for use in heat radiating articles which is made up at least in part of a plurality of filamentary plastics electrical resistance elements each of which consists of a uniform dispersion of conductive particles in a non-conductive plastics carrier material, and electrically conductive means forming part of said fabric to which said filamentary electrical resistance elements are connected, said conductive means being adapted to be connected to a source of electric current.

According to a particular feature of the present invention there is provided a heat radiating article including a fabric portion made up at least in part of a plurality of plastics filamentary electrical resistance elements, each of which consists of a uniform dispersion of conductive particles in a non-conductive plastics carrier material and electrically conductive means forming part of said fabric portion to which said filamentary electrical resistance elements are connected which means are adapted for connection to an electrical current source.

The plastics filamentary electrical resistance elements may be woven into the fabric by conventional means, and are preferably homogeneous in nature and, by virtue of possessing a non-linear positive temperature coefficient of resistance, the elements are self limiting in the maximum temperature obtainable. Preferably, the electrical resistance elements have a positive temperature coefficient which is greater than the temperature coefficient of the resistive substance, and the non-conductive carrier material has a specific electrical resistance and thermal coefficient of expansion, both much greater than those of the resistive substance.

The invention is further described with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic perspective view of a heat-radiating fabric illustrative of one embodiment of this invention;

Figure 2 is a fragmentary cross-sectional view taken on the line 2—2 of Figure 1;

Figure 3 is a fragmentary cross-sectional view taken on the line 3—3 of Figure 1;

Figure 4 is a diagrammatic top plan view of the heat-radiating fabric of Figure 1 showing the electrical circuit thereof;

Figure 5 is a diagrammatic illustration and electrical circuit layout of an alternative arrangement of a heat radiating fabric and its connection to an electric current source;

Figure 6 is a diagrammatic illustration and electrical circuit layout of another such arrangement; and

Figure 7 is a diagrammatic illustration and electrical circuit layout of still another such arrangement.

In accordance with the present invention, heat-radiating fabrics are provided which have application in home furnishings such as carpets, rugs, curtains, upholstery, blankets, tapestries, blinds, shades, etc., as well as in heated clothing such as socks, gloves, robes, suits, etc. These heat-radiating fabrics have heating filaments therein formed from an electrical resistance composition which will be hereinafter described.

As used herein the term "fabric" means any flexible material or article consisting substantially of filamentary or fibrous material, whether woven or non-woven. It includes, but is not limited to fabrics made by weaving, knitting, braiding. The term "filament" used herein includes both a single continuous strand of indefinite length and a plurality of strands which have been joined together, e.g. twisting.

The electrical resistance filaments used herein may be formed of an electrical resistance material having the following components: (1) one or more electrically resistive substances, and (2) a non-conductive carrier in which the resistive substance is homogeneously distributed. In addition, if desired, there may be included in the electrical resistive material at least one of the following: (a) an electrically insulating material, and (b) an oil having a very low dielectric loss factor which increases only slightly, if at all, with an increase in temperature.

The resistive substance may be one having either a negative or positive temperature coefficient. Any electrically conductive material substantially unaffected by air or moisture or by temperature of up to about 300°C. is suitable. The use of a moisture free resistive substance will avoid difficulties such as formation of bubbles and holes when the electrical resistance material is processed into a heating filament. Representative examples of resistive substances include carbon materials such as graphite, carbon black and lamp black; metal particles such as metal powders of copper, iron, zinc, magnesium, etc.; or particles of heating-wire alloys such as constantan and nickelin, or alloys such as monel metal (Registered Trade Mark) and phosphor-bronze. If desired, the resistive substance may be a mixture of two or more resistive substances, such as a mixture of graphite with carbon black, etc.

The non-conductive carrier material in which the resistive substance is distributed may be selected from any one of the following classes of plastics materials.

(a) polymers of substituted and unsubstituted alphaolefins such as polyethylene, polypropylene, polyisobutilene, polystyrene, etc.;

(b) copolymers obtained by polymerizing two different alpha-olefins such as those listed in (a);

(c) halogenated polymers and copolymers, such as for example, polyvinyl chloride, copolymers of vinyl chloride with vinyl acetate, styrene, propylene, etc.; polymeric halogenated hydrocarbons, e.g. polymers of tetrafluoroethylene etc.;

(d) polyesters, preferably unsaturated polyesters. These polyesters are plastic materials derived from the polymerization of esters in the presence of a peroxide which acts as a hardener. These esters are obtained by reacting an unsaturated dicarboxylic acid with a divalent alcohol. Examples of suitable polyesters are "Palatal P5" and "Palatal P6";

(e) polyamides, e.g. "Versamid" (a condensation product of dimerized and trimerized unsaturated fatty acids; in particular linolic acid with polyamides);

(f) other materials such as polacrylonitrile, polymeric vinyl amines and phenol waxes.

The polyolefins are the preferred non-conductive plastic carriers. However, any non-conductive carrier is suitable which has (1) its highest dielectric loss factor in the temperature range where substantial or maximum generation of heat is desirable (that is, up to the selected maximum operating temperature) and a dielectric loss factor that remains substantially constant or decreases beyond the selected operating temperature, and (2) a softening point substantially higher than the maximum operating temperature of the heating element.

The electrically insulating material (hereinafter simply referred to as "insulating material") that may be included in the electrical resistance material in addition to the resistive substance and the non-conductive carrier material should have the characteristic that its specific electrical resistance and its coefficient of thermal expansion are both higher than the specific electrical resistance and the coefficient of thermal expansion of the resistive substance. The electrically insulating material preferably should have a specific electrical resistance

greater than 10^{5} ohm-cm, and also preferably has a specific electrical resistance of at least 10^{5} times that of the resistive substance. The selection of electrically insulating materials is not critical so long as they meet the criteria mentioned above. The electrically insulating materials which may be employed may be either liquid, solid or tacky materials. Liquid insulating materials which have been found particularly suitable are electrically insulating oils including the following:

(a) Lubricating oils (a distillation product from crude oil, tar, or lignite products which are used for motors and machines). These oils preferably have a flame point of at least 200°C. Examples of such lubricating oils are "Mobil Vacra Oil No. 2, No. 3 and No. 4." These oils have a viscosity (centistroke) ranging from 37 to 99 at 50°C.

(b) Transformer oils (a chemically neutral mineral oil which is normally used as insulating filling for electrical transformers) such as, for example, "Univolt" oils.

(c) Silicone oils (linear-polymeric methyl silicone) e.g. methyl polysilixane. Preferably the silicone oil has a viscosity at 100°F, ranging from 100 to 20,000 centistokes.

(d) Paraffin oils (a petroleum fraction).

Also suitable as electrically insulating materials are soft pasty material such as natural or synthetic waxes and lubricating greases. Examples of waxes which may be employed include beeswax, carnauba wax, "Castorwax," etc. Also suitable are petroleum waxes, such as paraffin hydrocarbons and microcrystalline waxes. The lubricating greases which may be employed include homoegeneous mixtures of a motor lubricating oil with a metal soap such as obtained from the reaction of a metal hydroxide with a fatty acid. An example of such a metal soap is the lithium soap of 12-hydroxy stearic acid.

The electrically insulating material may also be a solid substance which is easily meltable below the operating temperature of the electrical resistance material. An example of such a material is acetyl cellulose sold under the trademark "Cellon." It is also possible to use as the electrically insulating material a solid material such as glass powder, finely divided bentonite, flint, etc.

As noted above, there may additionally be included in the electrical resistance material an oil which is characterized by having a low viscosity and particularly low dielectric loss factor (low dielectric constant and low dissipation factor) which increases only very slightly, if at all, with an increase in temperature. Typical oils which meet this requirement are oils having a dielectric constant (at 50 cycles) below about 2.3 at 60°C, a dielectric dissipation factor below about .001 at 60°C, maximum viscosity (centistokes) of about 5500 at 20°C and 500 at 50°C, and which may be primarily composed of 65 to 69% paraffin fraction, about 22 to 28% naphthene fraction and about 5 to 12% aromatic fraction.

There is a relatively wide range of proportions in which the above enumerated materials may be present in the electrical resistance material. The resistive substance either alone or in combination with the oil described above is preferably used in the electrical resistance material in an amount between about 60 to 110 per cent by weight of the non-conductive carrier. When an oil is included it is preferably present in an amount between 0.5 and 20 per cent by weight of the resistive substance, and is most preferably between about 5 and 10% by weight of the resistive substance. When it is desired to include an electrically insulating material in the liquid or pasty state (at room temperature) in the electrical resistance material, such a material may be present in an amount between about 7 and 25% by weight of the resistive substance, whereas when the electrically insulating material is a solid such as glass powder, it is employed preferably in an amount between 50 and 100 per cent by weight of the resistive substance. The reason for employing a greater quantity of the electrically insulating material when solid than when liquid or pasty is that the solid material does not have a thermal coefficient of expansion as great as that of the liquid or pasty material, and this factor is compensated for by employing more of the solid electrically insulating material.

The various electrical resistance materials described above, which are extruded into filaments as will later be described, may be prepared in a number of ways. If the electrical resistance material is to comprise only a resistive substance, disposed in a non-conductive carrier without any insulating material or oil, then the substance preferably in finely divided form (e.g. as a granular powder) is first mechanically premixed with the non-conductive plastics carrier material (e.g. polypropylene) which may be in powder or pellet form. The particles of resistive material preferably have a size of about 0.01 mm., but it is possible to employ a granular powder having a particle size between 0.002 and 0.1 mm. The non-conductive carrier material particles may have an even wider size range. The premixture of resistive substance and non-conductive plastics carrier is heated until a homogeneous product is obtained which can no longer be separated. For this operation a dispersion kneader, heated mixing rolls or the like may be used. If mixing rolls are used for homogenizing the materials, the temperature of the rolls is adjusted in accordance with the type of non-conductive plastics carrier material used. The resulting homogeneous mixture of resistive substance and non-conductive plastics is pelletized and then extruded into filaments.

If an electrical resistance material is desired in which there is incorporated an oil having

a low dielectric-loss-factor, the resistive substance,preferably in powder form and the oil may first be mixed in a high-speed fluid mixer for about 10 to 20 minutes at a temperature between about 60°C to 70°C. This mixing results in the greatest possible dispersion of the oil with the resistive substance. This mixture is then mixed with the non-conductive carrier material as previously described and extruded into filaments as indicated.

If an insulating material of the type noted above is to be included in the electrical resistance composition the following process is suitable. The resistive substance in finely divided form and having a particle size preferably within the range previously described is admixed with the selected insulating material (e.g. solid paste or lubricating oil). Thorough mixing is desirable in order to obtain a homogeneous combination of the resistive substance and the electrically insulating material. In this combination if a solid electrically insulating material is used the individual grains of the resistive substance are largely surrounded or enveloped by the particles of the electrically insulating material. If the electrically insulating material is a liquid, a doughy substance is produced by the mixing of the resistive substance with this material, so that the individual particles of the resistive substance are enveloped by the electrically insulating material. If the resistive substance employed is a porous carbon such as carbon black, and is mixed with a liquid electrically insulating material, the liquid material penetrates into the individual porous carbon particles. The envelopment or surrounding of the individual particles of the resistive substance by the electrically insulating material is not complete, as otherwise no flow of electric current would be possible. Therefore, in the mixture obtained by combining the resistive substance with the insulating material there is obtained a partial contact of the individual resistive particles of the resistive substance with one another throughout the mixture. This partial contact is sufficient for the current to flow through the individual particles.

The mixing of the resistive substance preferably in powder form with the electrically insulating material may be carried out in a suitable mixer. The time required for obtaining a homogeneous mixture is obviously dependent on the amount of material being admixed and the nature of the materials. The temperature employed during the mixing of the resistive substance and the electrically insulating material is selected in accordance with the particular electrically insulating material being employed.

The homogeneous mixture obtained by combining the resistive substance with the electrically insulating material is then dispersed in the non-conductive carrier material (e.g., polypropylene). This carrier acts primarily as a mechanical support for the resulting electrical resistance material. The introduction of the mixture consisting of the resistive substance and the electrically insulating material into the non-conductive carrier material is achieved according to techniques well known in the art, and is determined by the nature of the carrier and the homogeneous mixture. For example, the non-conductive carrier, may be blended with the homogeneous mixture (resistive substance plus electrically insulating material, if used) in a suitable mixer at temperatures well above the melting temperature of the plastics carrier. The resulting product may be pelletized and extruded to produce filaments, or may be directly extruded.

The mixing of the non-conductive plastics carrier with the homogeneous mixture of resistive substance and electrically insulating material may also be performed by dissolving the non-conductive plastics carrier material in a solvent having dissolving power for the particular plastics being used but inert relative to the homogeneous mixture. Among solvents which are suitable for this purpose are xylene, toluene, benzene, cyclohexane, heptane, dioxane, chloroform, acetone, methylethylketone, tetrahydrofuran and like solvents. The dissolved plastics carrier material is added to the homogeneous mixture and homogenized in a fast vibrating ball mill or the like.

Any conventional monofilament extrusion equipment may be employed to obtain the filaments. The die may be a straight manifold type, the die opening being a series of small round openings which commonly face downward. After the filaments leave the die, they are run through a quench tank containing water and then taken upon rolls. The diameter of the filaments is preferably in the range from about 6 to 60 mils.

If desired, the monofilaments may be drawn down to a diameter of about 1 mil according to techniques known in the art and subsequently joined together by twisting or the like to produce multifilaments which may be incorporated into the fabric material of this invention.

The electrical resistance materials described herein when extruded into filaments and those filaments incorporated into fabrics have been found to give excellent performance up to about 20 watts of heat dissipation per square foot.

The following examples are illustrative of electrical resistance materials extruded into filamentary strands in accordance with the present invention.

Example 1

A mixture of 100 parts by weight of resistive substance comprising 70 parts by weight of 10 micron flake graphite and 30 parts by weight of carbon black Columbia Carbon Company's "Statex B") is blended with 10 parts by weight of a electrically insulating

material (lubricating oil "Vactra No. 2" in a suitable mixer for 15 minutes at 60°C. The resulting powder is blended with polypropylene (type "EL Rex 11S15") in a suitable mixer for twenty minutes at a temperature of 380°F in the proportion of 65 per cent by weight polypropylene and 35 per cent by weight of the blend of the resistive substance and the electrically insulating material. The resulting homogeneous admixture is pelletized and then extruded at a temperature of 360°F into strands 8 mils in diameter.

The resulting filament has a room temperature resistance of about 45,000 ohms per inch.

EXAMPLE 2

The same procedure and materials are used as described in Example 1, except that 50 per cent by weight of the resistive substance blended with an electrically insulating material is combined with 50 per cent by weight of polypropylene. The resulting filament has a resistance of about 20,000 ohms per inch.

A desirable power dissipation for the heat-radiating fabrics of this invention is about 5 watts per square foot. Thus, for 120-volt applications, with filaments 24 inches long, the filament density would be 65 strands per inch using the 45,000-ohm filaments of Example 1. For 24-volt applications, if the filaments are 12 inches long, the filament density would be about 173 strands per inch using the 20,000-ohm filaments of Example 2. Using the filaments obtained according to Example 2, and having a length of 6 inches, requires about 43 filaments per inch.

Obviously the number of filaments per inch may be varied in accordance with the dissipation power desired, and using shorter lengths reduces the number of strands per inch necessary to obtain the desired dissipation power.

The following examples are illustrative of other electrical resistance materials which may be extruded into filaments in the manner described in the previous examples.

EXAMPLE 3

	Parts by Weight
Graphite (same as in Examples 1 and 2) (resistive substance)	100.00
Oil having low dissipation factor loss (An oil without added resin; this oil has viscosity of 500 centistokes at 50°C; a molecular weight of 670; a dielectric constant of 2.26 at 60°C and a dielectric dissipation factor of 0.001 at 60°C) (oil)	10.00
Polypropylene (Hostalen PPH — available from Farbwerke Hoechst) (non-conductive carrier)	100.00

EXAMPLE 4

Mixture of graphite and carbon black (70:30, same as in Example 1)	100.00
Polypropylene (same as in Example 3)	100.00

EXAMPLE 5

Graphite (same as in E xample 1)	85.00
Oil (same as in Example 3)	5.00
Polyethylene ("Lupolen" 1812 E — available from Badische Anilin-Soda Fabrik Co.)	100.00

EXAMPLE 6

Graphite (same as in Example 1)	90.00
Lubricating oil (same as in Example 1)	10.00
Polystyrene ("type 475 KH" — available from Badische Anilin-Soda Fabrik Co.)	120.0

Example 7	Parts by Weight
Graphite (same as in Example 1)	65.00
Lamp Black ("Corax L" — available from Degussa Co.)	35.00
Lubricating oil (same as in Example 3)	10.00
Polyester ("Palatal P5" — available from Badische Anilin-Soda Fabrik Co.)	130.00
Example 8	
Graphite (same as in Example 1)	80.00
Iron powder	20.00
Beeswax	15.00
Polyamide ("Versamid" — available from Schering A.G.)	150.00
Example 9	
Graphite (same as in Example 1)	75.00
Lamp black (same as in Example 7)	15.00
Beeswax (same as in Example 8)	10.00
Polystyrene (same as in Example 6)	200.00
Example 10	
Graphite (same as in Example 1)	33.00
Iron powder (same as in Example 8)	9.00
Methyl silicone oil (type M1000 — available from Wacker Chemie Company)	5.00
Polyamide (same as Example 8)	57.00
Example 11	
Graphite (same as in Example 1)	100.00
Methyl silicone oil (same as in Example 10)	20.00
Polyvinyl chloride (type "Vinnol P 100" — available from Wacker Chemie)	120.00

EXAMPLE 12

	Parts by Weight
Graphite (same as in Example 1)	100.00
Lamp black (same as in Example 8)	10.00
Acetyl cellulose ("Cellon" (Registered Trade Mark) — available from Dynamit Nobel A.G.)	10.00
Polyisobutylene ("Oppanol B" — available from Badische Anilin-Soda Fabrik)	150.00

The heat-radiating articles of this invention are preferably composed at least in part of natural or synthetic fibers, the selection of which depends on the end use contemplated for the fabric. Illustrative of fibers for making fabrics include: nylons, e.g. polycarprolactam, polyhexamethylene adipamide, polyhexamethylene sebacamide, as well as other polyamides; polyesters, e.g. polyethylene terephthalate; celluloses, e.g. cotton, viscose rayon, cellulose acetate, alginate, cuprammonium rayon, etc.; acrylics, e.g. copolymers of acrylonitrile with vinyl acetate or acrylic esters; polylefines, e.g. polypropylene, polyethylene, etc.; proteins, e.g. wool, caein, zinc, etc.; vinyls, e.g. polyvinyl alcohol, polyvinyl acetate, polyvinylchloride; fluorocarbons, e.g. polytetrafluoroethylene; polyurethanes, e.g. those sold under the Trade Mark " Lycra ".

The manner of incorporating the electrical resistance filaments into fabrics will now be described with reference to the drawings.

Referring first to Figures 1—4, in Figure 1 there is shown a diagrammatic perspective view of a carpet 10 comprising a woven pile fabric 11 and a backing 12 secured to the pile fabric 11 by adhesive, or the like.

The pile fabric 11 comprises a plurality of warp threads 13 and a plurality of weft threads 14 woven by known weaving means, and is illustrated in Figures 2 and 3. The pile or nap 24 of the pile fabric 11 may be formed in any conventional manner, but as shown, comprises a plurality of fiber threads 25 which may be secured to the warp in any conventional manner such as by frictional engagement between the adjacent warp and weft threads or by knitting. A plurality of plastics filamentary electrical resistance elements 15, whose composition and manufacture have been described in the above examples, may be woven into the pile fabric either as warp or weft threads in one direction only. The filamentary electrical resistance elements are illustrated in Figure 1 as being woven into the fabric as weft threads. The number of such filamentary electrical resistance elements per inch of woven fabric may be varied as heretofore described, to obtain desired power dissipation values. The filamentary electrical resistance elements are connected with an electric current source 16 by means of terminal leads 17 and 18 and conductive elements 19 and 20. Each of the conductive elements 19 and 20 may comprise fine copper wire or the like and may be woven into the fabric, either as warp or weft threads depending upon the direction the filamentary electrical resistance elements are woven into the fabric.

The general arrangement of the resistance elements 15 and conductive elements 19, 20 in one form may be as shown in Fig. 4, from which the normal carpet warp and weft threads have been omitted for clarity. Here, the resistance elements 15 run horizontally of the figure, preferably but not necessarily equally spaced and at at each end contact the vertically running conductive elements 19, 20 which act as distributors to feed current to the resistance elements 15 in parallel. It will be understood that the diameter, resistivity and number of filamentary resistive elements per inch are chosen in relation to the applied voltage, to produce the desired power dissipation for the heating purpose at hand.

The conductive elements 19, 20 may be sewn rather than woven in place, or alternatively may be formed of foil strip suitably adhered to the edges of the fabric to maintain contact with the resistance elements 15, or may be a conductive strip painted or deposited on the fabric edges in contact with the resistance elements 15 or formed in other ways suitable for connecting the resistance elements 15 to source 16.

In some fabrics, the spacing between conductive elements 19, 20 (when at the fabric edges) may be longer than desired. An alternative arrangement is shown in Fig. 5, in which subsidiary conductive elements 21, 22 extend horizontally from each main element 19 or 20 toward the other, either terminating before

reaching the opposite main element, or crossing it in spaced insulated relation, as at 119, 120, for example. In this case the resistance elements 15 run vertically in the figure, in electrical contact with the conductive sub-elements 21, 22 that they cross. Thus, the spacing between adjacent conductive sub-elements 21, 22, determines the effective length of resistance elment 15 across which the source 16 voltage is applied, permitting any desired effective length, independent of the fabric width.

Another arrangement is shown in Fig. 6, in which a plurality of conductive elements extend vertically in the figure, alternate ones such as 19, 19a being connected together at one end to one terminal 17 and the intermediate ones, such as 20, 20a, being connected together and to the other terminal 18. In this way also, the effective length of the horizontally extending resistance elements 15 may be selected as desired, by suitably choosing the spacing between adjacent conductive elements. It will be understood that any desired number and spacing of conductive elements may be used as circumstances dictate.

When the conductive elements are spaced at a substantial distance from each other, e.g. more than about 12 inches, it may be desirable to wave into the fabric intermediate floating elements 23 which are not connected with the current supplying elements 19, 20, 21, 22. These floating elements 23 which may be spaced apart at any desired distance, are woven in the pile fabric of the carpet either parallel or at right angles to conductive elements 19, 20, so long as they are at an angle (preferably a right angle) to the resistance elements 15. For example, Fig. 7 shows an arrangement similar to Fig. 4, but with added floating conductive elements 23, interposed between the conductive elements 19, 20 and parallel therewith. Floating elements 23 are not directly connected to the current supplying elements 19, 20, except through the resistance elements 15.

The desirability of using floating elements 23, arises from the special property of the resistance elements 15, that when heat dissipation from a local area of an element 15 is impaired, this material substantially increases its resistivity, which may block current flowing in the elements 15 and reduce heat dissipation from other areas through which the same elements extend, even though spaced from the blocked area. If this should happen, then floating elements 23 would distribute current to such other areas, notwithstanding that the resistivity of some elements 15 may be increased in the blocked area.

Such floating conductive elements may be used with any configuration of resistance and conductive elements, but should be kept out of direct contact with the current-supplying conductive elements, which may be accomplished by any techniques well known in the art.

Other modifications in the construction of the heat radiating articles are possible. For example, the conductive elements may be secured to the pile fabric by stitching, cementing or other means rather than being woven into the fabric. Similarly, the filamentary resistance elements need not necessarily be woven into the fabric, but may be secured thereto by other suitable means such as cementing, stitching, etc. Also the conformation of the conductive elements is not critical, except to the extent that they should be pliable if the heat radiating article is itself pliable.

In any of the above forms of the invention, where two conductive elements are joined, their electrical connection may be made by spot-welding or soldering, or in many cases merely by their contact with one another, since their contact resistance will be low relative to the resistance of the resistance elements fed thereby.

Since both the filamentary electrical resistance elements described herein and the electrically conductive elements may be woven into a fabric by conventional techniques, heat-radiating draperies and other articles may be manufactured which maintain their decorative appearance because both the heating elements and the conductive elements are an integral part of the fabric. In addition, the filamentary electrical resistance elements may be incorporated into knitted or non-woven fabrics to provide heat-radiating articles such as socks, gloves, and other wearing apparel.

The words Palatal, Versamid, Lupolen, Corax, Hostalen, Oppanol, Lycra, Mobil and Univolt used herein are all Registered Trade Marks.

WHAT WE CLAIM IS:—

1. A fabric for use in heat radiating articles which is made up at least in part of a plurality of filamentary plastics electrical resistance elements each of which consists of a uniform dispersion of conductive particles in a non-conductive plastics carrier material, and electrically conductive means forming part of said fabric to which said filamentary electrical resistance elements are connected, said conductive means being adapted to be connected to a source of electric current.

2. A fabric according to claim 1 wherein said electrically conductive means include at least two spaced conductive members in electrical contact with at least some of said filamentary electrical resistance elements.

3. A fabric according to claim 2 wherein said conductive elements extend along said fabric substantially at right angles to the direction of said filamentary electrical resistance elements.

4. A fabric according to any of claims 1—3 wherein said filamentary electrical resistance

elements extend along said fabric in one direction only.

5. A fabric according to any one of claims 1 to 4 wherein said electrically conductive means include two spaced terminal members adapted to be connected to respective terminals of an electrical current source and a plurality of intermediate conductive elements located between said terminal members, at least some of said intermediate conductive elements intersecting and being in electrical contact with said plastics filamentary electrical resistance elements at their points of intersection.

6. A fabric according to claim 5 wherein alternate ones of said intermediate conductive elements are connected to the same terminal member.

7. A fabric according to claim 5 or 6 wherein the terminal members and the intermediate conductive elements are woven in the fabric and the fabric is a woven fabric.

8. A fabric according to claim 7 wherein the filamentary electrical resistance elements and the conductive elements are woven substantially at right angles to each other.

9. A fabric according to any of claims 1 to 4 wherein the electrically conductive means includes two spaced terminal members adapted to be connected to respective terminals of an electrical current source to which the filamentary electrical resistance elements are electrically connected, and a plurality of intermediate conductive elements located between said terminal members and lying in the same general direction, the intermediate conductive elements being at an angle to the plastics filamentary electrical resistance elements and in electrical contact therewith at their points of intersection, and said intermediate conductive elements being in a non-electrical contact relationship with the terminal members.

10. A fabric according to any one of claims 1 to 4 wherein said electrically conductive means includes two opposed spaced terminal members adapted to be connected to respective terminals of an electrical current source and a plurality of intermediate conductive elements lying at an angle to said terminal members and said plastics filamentary electrical resistance elements, alternate ones of said intermediate conductive elements being in electrical contact with a respective terminal member.

11. A fabric according to claim 9 or 10 wherein the filamentary electrical resistance elements extend along the fabric in one direction only and said intermediate conductive elements and said filamentary electrical resistance elements are woven in said fabric.

12. A fabric according to claim 11 which includes the said terminal member is woven into said fabric.

13. A fabric according to any of the preceding claims wherein the said resistance elements comprise said conductive particles and said non-conductive plastics carrier material has a specific electrical resistance and coefficient of thermal expansion which are both greater than that of said conductive particles.

14. A fabric as claimed in any preceding claim wherein said filamentary plastics electrical resistance elements have a positive temperature coefficient of resistance and operate during the passage of current therethrough to automatically increase and decrease the resistance of individual areas of said filamentary elements in accordance with the dissipation of heat from said individual areas.

15. A fabric according to claim 13 or 14 wherein said filamentary electrical resistance elements include in addition, dispersed in said non-conductive plastics carrier material at least one component selected from (1) an oil of low viscosity, low dielectric constant and dissipation factor, said oil being present in said filamentary electrical resistance elements in an amount between about 0.5 to about 20% by weight of the said conductive particles and (2) an electrically insulating material having a specific electrical resistance greater than 10^{5} ohm-cm, said electrically insulating material having a greater coefficient of thermal expansion than said resistive substance and being present in said filamentary electrical resistance elements in an amount between about 7% and about 25% by weight of the said conductive particles.

16. A fabric according to any of claims 13 to 15 wherein the non-conductive carrier material has a dielectric loss factor which remains substantially constant or decreases beyond the maximum operating temperature of the filamentary electrical resistance elements.

17. A fabric according to claim 16 wherein the non-conductive carrier material is a polypropylene.

18. A fabric according to claim 15 or any appendant thereto wherein the electrically insulating material is selected from lubricating oils, transformer oils, silicone oils, and paraffin oils.

19. A fabric according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

20. A heat radiating article which includes a fabric according to any of claims 1—18.

21. A carpet which includes or which consists of a fabric according to any of claims 1—18.

22. A heat radiating article including a fabric portion made up at least in part of a plurality of plastics filamentary electrical resistance elements, each of which consists of a uniform dispersion of conductive particles in a non-conductive plastics carrier material and electrically conductive means forming part of said fabric portion to which said filamentary electrical resistance elements are connected which means are adapted for connection to an electrical current source.

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Reference has been directed in pursuance of Section 9, sub-Section (1) of the Patents Act, 1949, to patent No. 1,053,331.

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1205666 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1.

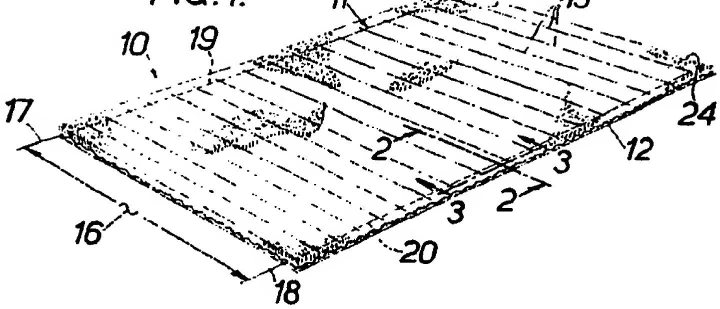


FIG. 2.

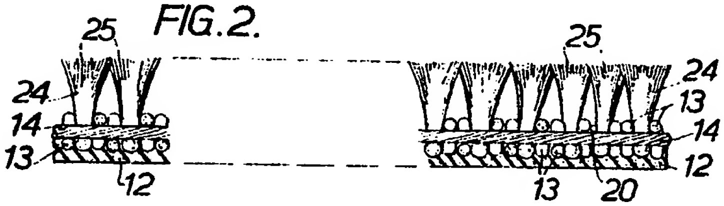
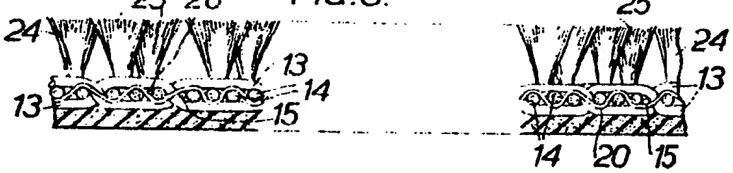


FIG. 3.



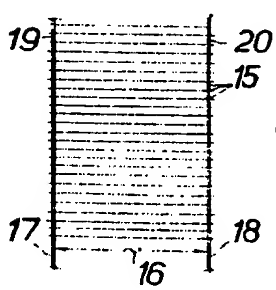


FIG. 4.

FIG.5.

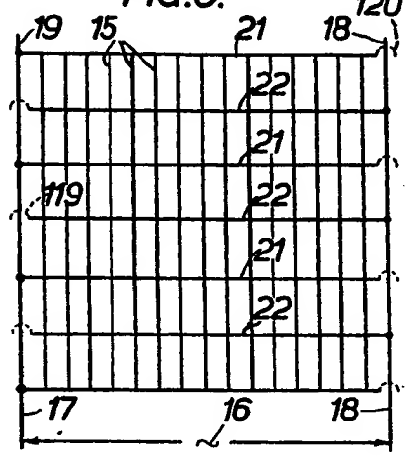
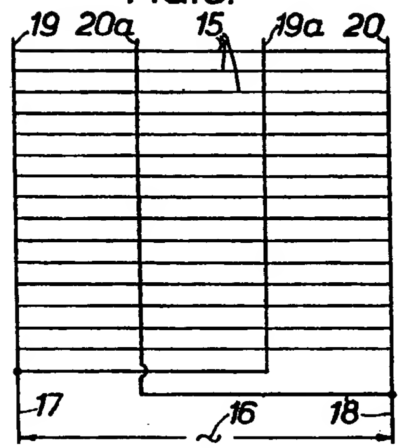


FIG.6.



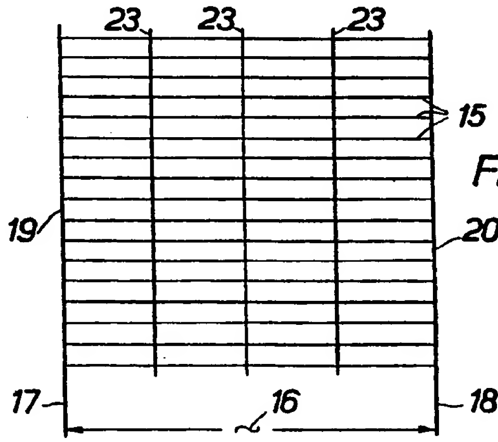


FIG.7.